

Dry Eye After LASIK Surgery: Comprehensive Review and Update of Literature

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ABSTRACT

Laser in situ keratomileusis LASIK is an effective method to correct refractive errors; it is safe with good outcomes and few complications. Dry eye is considered by far the most common complication after LASIK. The pathophysiology of this eye dryness involves nerve damage and inflammatory processes. Treatment of dry eye is mainly by the use of artificial tears, botulinum toxin and plasma rich in growth factors. Small incision lenticule extraction SMILE is a new refractive surgery modality with better outcomes and less incidence of dry eye compared to LASIK. An extensive literature search was carried out to achieve the aim of reviewing the relevant literature and updating the current knowledge about post-LASIK dry eye incidence, symptoms, risk factors and possible treatment modalities. Studies included were from 2000 to 2023, with observational, interventional and review study designs. Case reports, case series and commentaries were excluded from this review.

Keywords: Dry eye, LASIK, refractive surgery, SMILE, Review

INTRODUCTION

Laser in situ keratomileusis LASIK is an effective method to correct refractive error. It is safe with good outcomes and few complications, yet it is a quite popular operation, with more than 1 million undergoing this procedure annually in the United States alone. Nevertheless, frequent follow-up is needed to guard against regression of the corrected refractive error and post-LASIK dry eye. Dry eye is considered the most common complication after LASIK. Its incidence may approach 47% at 1 week after surgery^{1,2}.

Although the pathophysiological aspects of dry eye after LASIK surgery are not well understood, several studies demonstrated that it could be due to damage of sensory nerves in the cornea and an inflammatory process that involves activation of T-lymphocytes and cytokines release^{3,4}. Risk factors for developing chronic dry eye after LASIK surgery include female gender, elderly patients, Asian race, and higher level of refractive correction⁵⁻⁷.

Reported symptoms suggestive of dry eye include eyes being sensitive to touch, sharp pain and sticking of the eyelids to the eyeball⁸. Treatment of these symptoms and other manifestations of dry eye is mainly by using artificial tears; eye drops containing antibiotics and cortisone can also be used. Nevertheless, a recent study suggested eye drops of growth factors-rich plasma as an effective treatment for post-LASIK dry eye with no reported adverse effects^{4,9}.

Small incision lenticule extraction SMILE is a newly invested minimally invasive surgical modality that uses femtosecond laser; compared to the classical LASIK surgery, SMILE is less invasive with a lower incidence of post-operative dry eye^{10,11}. This study aimed to

review the relevant literature and update the current knowledge about post-LASIK dry eye incidence, symptoms, risk factors and possible treatment modalities. In addition, to briefly compare LASIK with other refractive surgical modalities.

Epidemiology:

A dry eye after LASIK surgery is a major factor in the patient's dissatisfaction with this operation. Up to 95% of patients who underwent this surgery reported at least some dry eye symptoms. A study from Iran followed 190 patients for 6 months post-operatively and reported that 20% of the study participants were affected by chronic dry eye, significantly reducing tear film stability and volume^{7,12}.

The incidence of dry eye could differ according to the technique used in LASIK surgery. A randomized controlled trial evaluated the incidence of dry eye after LASIK, defined by corneal fluorescence staining more than or equal to 3, with the evaluation of visual acuity and parameter of ocular surface. Patients were divided into two groups superior-hinge hantatome microkeratome VS nasal-hinge Amadeus microkeratome. The comparison of 6 months follow-up results is summarized in the **table 1. 2**

Another prospective randomized trial compared the effect of hinge position on pre and post-operative corneal sensation. Dry eye symptoms were more prevalent with superior-hinge flap and less with nasal-hinge flap. When compared with the preoperative values of corneal sensation assessment, there is a statistically significant reduction $P = 0.001$ with superior-hinge flaps at 6 months follow-up, yet no statistically significant difference $P = 0.263$ with nasal-hinge flaps¹³.

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Table 1: Incidence of dry eye after LASIK according to different techniques at 6 months follow up n=17

Incidence	1 week	1 month	3 months	6 months
superior-hinge hansatome microkeratome	52%	41%	17%	35%
nasal-hinge Amadeus microkeratome	47%	38%	25%	12%

Pathophysiology:

Although the exact pathophysiological mechanisms underlying the occurrence of dry eye after LASIK surgery are not fully understood, many studies have attempted to investigate this area, as dry eye is a quite common phenomenon, with high incidence after refractive surgeries leading to patient dissatisfaction. The most important etiology is what is named LASIK-induced neurotrophic epitheliopathy LINE, which is due to the transaction of afferent sensory nerves that are responsible for sending sensory stimuli to the brain stem, which then send response via efferent autonomic fibers to stimulate tear secretion from lacrimal glands. This decrease in tear secretion due to neurotropic mechanisms renders eyes more susceptible to inflammation. The inflammatory hypothesis suggests the involvement of T-lymphocytes, adhesion molecules and different cytokines with increased activity of matrix-degrading enzymes such as MMP-9. This will activate a vicious cycle of dryness, inflammation, and dryness.^{3,4,14}

Another hypothesized mechanism involved in the pathophysiology of dry eye after LASIK includes conjunctival goblet cells damaged during the procedure by suction machines or by the flaps created by the femtosecond laser and microkeratome. Changes in corneal shape and alteration of its curvature are other mechanisms of eye dryness; this can lead to abnormal tear distribution with blinking. Post-operative treatments like non-steroidal anti-inflammatory drops NSAIDs, antibiotics, and preservatives can also induce transit damage.^{12,15}

Risk factors:

Sociodemographic characteristics

Demographic characteristics associated with a higher incidence of dry eye include older age P, 0.001, female gender P = 0.005 and Asian race p < 0.001.^{6,7}

Preoperative characteristics

Preoperative dry eye is a major risk factor for postoperative dry eye; therefore, any candidate for refractive surgery should be examined and questioned about dry eye symptoms before surgery. Different tests, including tear breakup time, Schirmer test, and ocular surface staining, can assess dry eye. Nevertheless, measurement of tear osmolarity gives valuable assessment for the severity of dry eye preoperatively. Any symptoms of dry eye or ocular surface abnormalities should be corrected preoperatively to decrease the incidence of post-operative dry eye. Other factors that are involved in the occurrence of dry eye is preoperative use of contact lens, the degree of preoperative myopia, lower preoperative spherical equivalent, and preexisting medical issues like eyelid anomalies and diabetes mellitus.^{2,4,12}

Operative technique/ factors

Higher levels of refractive correction and greater ablation depth are associated with a higher risk for postoperative dry eye⁷. Although there is a difference in dry eye incidence between superior-hinge and nasal-

hinge techniques of LASIK, the difference doesn't approach statistical significance during the 6-month follow-up.²

Signs and symptoms

Symptoms suggestive of the post-operative dry eye include ocular fatigue, irritation and dry eye. Clinical signs for dry eye can manifest as positive vital staining of the ocular surface at the corneal flap site, measured by rose bengal, fluorescein, and lissamine green. Also, tear breakup time measured by the Schirmer test can be decreased up to 6 months postoperatively.¹⁶

A study by Hovanesianet *al.* compared the frequency and severity of dry eye symptoms between photorefractive keratectomy PRK and laser in situ keratomileusis LASIK. They concluded that symptoms of dry eye were reported by 9.1% of participants who underwent PRK and 8.7% of those who underwent LASIK surgery. The frequency of post-operative dry eye symptoms was correlated with patients satisfaction with the procedure P = .001, relative risk 2.0 and their willingness to have surgery again in the future P = .001, relative risk 2.2. More details are shown in table 2.⁸

Table 2: Frequency of symptoms compared by type of refractive surgery

	LASIK	PRK	p-value	relative risk
soreness to touch	1.6%	7.8%	.0001	5.1
eyelid-sticking	0.9%	4.3%	.0005	4.9
frequent sharp pains	0.4%	2.2%	.005	6.1
severe sharp pains	0.2%	4.3%	.0001	24.8

Prevention

As the main pathophysiological mechanisms underlying post-LASIK dry eye are neuropathic pain and destruction of nerves, gaba pentinoids gabapentin and pregabalin have been suggested preoperatively for prevention of post-operative dry eye symptom, nevertheless, in the context of LASIK surgery this was only tested in animal models, and its efficacy in humans is still to be tested.¹⁷

TREATMENT

Dry eye is a prevalent complaint after LASIK surgery and a major cause of patients' discomfort and dissatisfaction. Different treatment modalities were invested; these are summarized below.

Tear Supplements

Artificial tears were the mainstay treatment of dry eye after refractive surgery; it is recommended that artificial tears should be used without preservatives, as it has a toxic effect on the ocular epithelium. The types of commercially available preservative-free artificial tears include hyaluronic acid .1% or .5%, diqua fosol tetrasodium ophthalmic solution and rebamipide mucin supplement.^{4,16}

Autologous serum eye drops can also be used. They are rich in neurotrophic factors like NGF that enhance nerve growth after LASK surgery. Nevertheless, a prospective randomized trial demonstrated no significant difference in the dryness symptoms between autologous and artificial tear usage after LASIK.¹⁷

Anti-Inflammatory Agents

Previously, topical corticosteroids like methylprednisolone were used

as anti-inflammatory agents for treating the different inflammatory processes underlying dry eye. Nevertheless, despite having a rapid anti-inflammatory action, steroids are not advisable for long-term use due to their eye complications cataract and glaucoma.

The alternative is using cyclosporine ophthalmic emulsions as it induces immune modulation rather than immune suppression. It suppresses the inflammatory process by inhibiting T-cell recruitment and lymphocyte infiltration. It also increases the goblet cell's number and enhances tear production.^{4,16}

Botulinum Toxin A

Fouda *et al.* reported the effective use of botulinum toxin injection to control dry eye symptoms post-LASIK. Botulinum toxin acts by inducing punctalectropion. Patients treated with this method reported higher levels of satisfaction and few complications from this treatment modality.¹⁸

Lacrimal Punctal Plugs

Using punctal plugs is a safe and effective method to treat chronic dry eye after LASIK surgery; it increases goblet cell density and improves dryness symptoms. This modality is shown to be superior to cyclosporine in the short term, as evident by more improvement in Schirmer test scores. However, in the long term, the difference is not statistically significant; however, punctal plugs and cyclosporine can be used in combinations.^{4,16}

Plasma Rich in Growth Factors PRGF

PRGF eye drops are reported to be an effective treatment for dry eye symptoms in patients who underwent LASIK surgery. When compared to conventional treatment of eye dryness, PRGF demonstrated better improvement in the Schirmer test as a measurement of tear volume 88.9% increase in the Schirmer test after PRGF, and 4% increase in the conventional therapy group and more tear stability measured by TBUT

Table 3: Summary of relevant studies comparing dry eye parameters in SMILE and LASIK

Title	Study design	Date	reference
Dry Eye After Small Incision Lenticule Extraction and LASIK for Myopia	a nonrandomized, interventional, prospective study	2014	22
Dry eyes after SMILE	Review article	2019	21
Dry eye disease after refractive surgery	Prospective nonrandomized clinical trial	2014	10
Dry Eye After Small Incision Lenticule Extraction and Femtosecond Laser-Assisted LASIK: Meta-Analysis	Meta-Analysis	2017	11
Small incision lenticule extraction SMILE history, fundamentals of a new refractive surgery technique and clinical outcomes	Review article	2014	20
Dry eye after refractive surgery: A meta-analysis	Meta-Analysis	2019	23

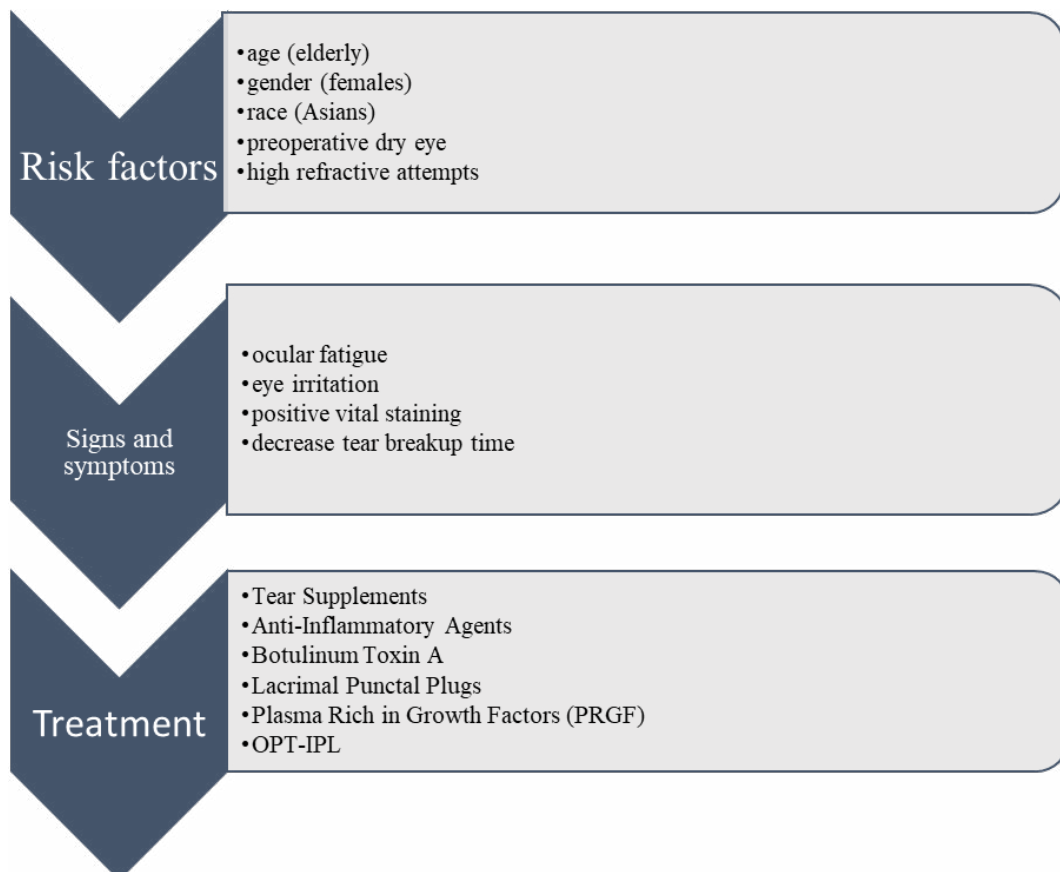


Figure 1: Summary of important risk factors, signs and symptoms, and different treatment modalities of dry eye after LASIK

p-value < 0.05. Nevertheless, no adverse effects were reported from the PRGF treatment modality.⁹

OPT-IPL

Optimal pulse technology-intense pulse light OPT-IPL was invested as a new modality to treat refractory dry eye post-LASIK. It improves tear film stability, enhances functions of the meibomian gland, and decreases the severity of refractory dry eye symptoms.¹⁹

PROGNOSIS

Although difficult to predict, post-LASIK dry eye usually lasts about 1 month postoperatively. Nevertheless, patients may continue to experience dry eye symptoms up to one year after surgery. The incidence of this chronic post-LASIK dry eye is about .8% after 1 year of follow-up.¹⁶

LASIK VS SMILE

Small incision lenticular extraction SMILE is a relatively new surgical approach, and it operates by inserting a small incision to remove the lenticula and, hence, no need for flaps.²⁰ Despite having better outcomes and fewer complications than other refractive surgeries, SMILE can also precipitate post-operative eye dryness. The mechanisms underlying this eye dryness included decreased sensation over the cornea due to disruption of its innervation, goblet cell damage by suction, and inflammatory processes of the cornea.²¹

Since the application of SMILE surgery, several studies compared dry eye parameters between LASIK and SMILE, their outcome being almost the same. SMILE had a less adverse effect on corneal innervation; thus less dry eye symptoms were experienced by patients who underwent SMILE compared to those who underwent LASIK. 10,11,22,23 A summary of these studies is presented in **Table 3**.

LIMITATIONS

This study is limited by the narrative approach of reviewing the relevant literature. Yet, it provides valuable insight into current updates about dry eye after LASIK, as well as briefly reviewing new modalities of refractive surgery.

CONCLUSION AND FUTURE PERSPECTIVES

In summary, this study reviewed different aspects of dry eye after refractive surgery, including epidemiological studies, symptoms and risk factors for dry eye, different treatment modalities and a comparison between LASIK and SMILE regarding incidence of dry eye symptoms.

Further studies are needed in this area to evaluate the incidence and severity of dry eye symptoms among patients who underwent LASIK surgery to decrease its occurrence and, hence, increase patient satisfaction with LASIK outcomes.

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Competing Interest: None

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